



Electronic structure of superconductivity refined

July 10, 2008



LOS ALAMOS, New Mexico, July 10, 2008— A team of physicists, including Neil Harrison and Charles Mielke from Los Alamos National Laboratory, propose a new model that expands on a little understood aspect of the electronic structure in high-temperature superconductors. The research represents a step toward figuring out the mechanics of superconductivity – the phenomenon that could revolutionize energy efficiency in such areas as mass transportation, electricity transmission, and power storage.

The team, which includes scientists from Cambridge University, the University of British Columbia, and the National High Magnetic Field Laboratory (NHMFL), reports its findings in the July 10 edition of *Nature* in a letter titled “A multi-component Fermi surface in the vortex state of an underdoped high- T_c superconductor.” The NHMFL is a joint research venture sponsored by the National Science Foundation and the Department of Energy with campuses at Los Alamos National Laboratory, Florida State University, and the University of Florida.

Since the discovery of ceramic materials containing copper oxide that can conduct electricity with no resistance at relatively high temperatures – at least above the temperature of liquid nitrogen (approximately -320° F) – it has been thought that changes in the behavior of a single carrier type were governing this unusual property. Now, this multinational group of collaborators has put forth the idea that two types of carriers may be involved.

Experiments made just last year revealed the existence of electron carriers. These are, atomically speaking, very light and thinly spread, so they wouldn't be likely to have a great effect on the behavior of a compound throughout the relevant temperature range. But a second type of carrier, called holes, which are heavier and more numerous, might better help explain the origin of superconductivity.

Harrison and his colleagues believe this might help explain why, in the presence of strong magnetic fields like the ones used in the team's experiments, superconductivity coexists with a state known as antiferromagnetism, which appears wherever the magnetic field punches holes through the superconductor in the form of vortices.

"Uncovering the relationship between the electronic structure and the interplay between superconductivity and other competing phases like antiferromagnetism is an important milestone toward the eventual understanding of high-temperature superconductivity," Harrison said. "The process by which they switch their involvement from one to the other is likely to be of central importance to the superconducting pairing mechanism itself."

Harrison's experience with what's known as the magnetic torque technique helped the scientists draw their conclusions. Electrons in these superconducting compounds, he said, move in layers, seldom crossing from one to another. But, if the sample is set on an incline and exposed to a magnet with a field thousands of times stronger than the Earth's, the electrons scramble to align themselves. This unusual movement produces measurable torque, which enabled the scientists to spot the dominant player in the equation – the holes.

As they learn more about the peculiarities of superconductivity, physicists hope to push the temperature at which resistance-conduction is possible. "Obtaining higher-temperature superconductivity, with the goal of achieving greatly more efficient power lines and generators, lies at the very heart of the nation's quest for better energy efficiency," Harrison said.

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